ROYAL GARDENS, KEW.

BULLETIN

OF

MISCELLANEOUS INFORMATION.

No. 32.] AUGUST. [1889.

THE FLUTED SCALE-INSECT.

(*Icerya Purchasi*, Maskell.)

With Plate.

An insect which ranks amongst one of the most destructive pests injurious to plants has made its appearance of late years in South Africa, New Zealand, and California. It belongs to the family Coccidæ or scale insects, and is known under various popular names. In South Africa it is called "the Australian Bug"; in New Zealand, the "Cottony Cushion-scale"; and in California it is indifferently the "White scale," "Ribbed scale," or "Cottony Cushion-scale." Professor Riley, who has thoroughly investigated its life-history, suggests that the insect be known as the "Fluted scale." Mr. Maskell first described the species from New Zealand specimens, in 1878 (New Zealand Trans., Vol. XI., 1878, p. 221), and whatever diversity may exist as regards its popular name, it is now known to science as *Icerya Purchasi*, Maskell.

It was first observed in South Africa at Cape Town in 1873. In 1876 it had spread to the neighbouring division of Stellenbosch, and is

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now more or less prevalent throughout the Colony. Mr. Roland Trimen, F.R.S., states that (in 1887) "the orange industry of the western districts " (of Cape Colony) has suffered most severely; scarce, very inferior, and " exceedingly dear fruit being now only obtainable where it used to be " abundant, good, and cheap." He further remarks, "the 'bug' has " spread to Natal within the last few years, and last year I received " specimens from there found on the common Wattle (Acacia). " Only yesterday (7th February 1887) I was sorry to receive a lot " found there on the orange."

In New Zealand *Icerya Purchasi* is described as "having destroyed " whole orchards of orange trees in Auckland; and in Nelson and " Hawke's Bay it is a dreaded pest on all kinds of plants."

Indeed, Mr. Maskell states that it "is so voracious and universal a " feeder, so repulsive in its aspect, and so destructive in its effects that, " in spite of kerosene mixtures which undoubtedly destroy it, the most " drastic remedy is the best. Anyone, therefore having a tree, espe- " cially an ornamental or a fruit tree, attacked by *Icerya Purchasi*, is " strongly recommended to make no delay, but to cut down and burn " every stick of the tree as soon as possible."

Professor Riley received the first American specimens in 1872 from San Francisco, and he is of opinion that "all evidence points to its " introduction into California about 1868, and probably from Australia " on *Acacia latifolia*." It is now "a formidable pest, and has gained " such hold on the orange groves in California in spite of the most " strenuous efforts, that the people find it impossible to keep it down."

Before proceeding to give a general account of *Icerya Purchasi*, and the various steps that have been taken to deal with it, it may be well in the first place to quote Mr. Maskell's description as given in *An Account of the Insects noxious to Agriculture and Plants in New Zealand*, pp. 104–7 :—

Genus : *Icerya*, Signoret.

Adult females having antennæ of 11 joints; covered with thin mealy secretion or with cotton; stationary; with or without ovisac. Rostrum and mentum present. Segmentation inconspicuous.

Adult males without tassels on the abdomen; antennæ with two dilations on each joint.

Two species only of this genus are at present known, the one described below and another, *I. sacchari*, infesting sugar-canes in Mauritius. The male of the latter is unknown. Possibly researches in Australia might result in the discovery of others.

Icerya Purchasi, Maskell.

(The "Cottony Cushion-scale.")

N.Z. Trans., vol. xi., 1878, p. 221; vol. xvi., 1883, p. 140; vol. xvii., 1884, p. 30; vol. xix., 1886, p. 45.

Adult female dark reddish-brown, covered with a thin powdery secretion of yellowish meal, and with slender glassy filaments; stationary at gestation, and gradually raising itself on its head, lifting the posterior extremity until nearly perpendicular, filling the space beneath it with thick white cotton, which gradually extends for some distance behind it in an elongated white ovisac, longitudinally corrugated; ovisac often much longer than the insect, and becoming filled with oval red eggs. Length of female about $\frac{1}{5}$ in., reaching sometimes nearly $\frac{1}{3}$ in. Body previous to

gestation lying flat on the plant, the edge slightly turned up; on the dorsum a longitudinal raised ridge, forming one or more prominences. Insect covered all over with numerous minute fine hairs, most thickly on the thoracic region; round the edge these hairs are longer, and are arranged in tufts somewhat closely set; the tufts are black, and contain from 20 to 30 hairs in each. Amongst the hairs in the tufts are several protuding tubular spinnerets, having on the outer end a kind of multiglobular ring or crown; from these proceed cylindrical, glassy, straight tubes as long as the tufts of hair. Long, fine, glassy, delicate filaments, as long as the body of the insect, radiate from the edge all round; but these, being very fragile, are often irregular or absent. During gestation thick, short, cottony processes form at the edge of the thorax, seemingly attached to the feet. Antennæ of 11 joints, very slightly tapering; each joint bearing hairs. Feet normal, somewhat thick. Rostrum not long; mentum triarticulate. Procreation commencing soon after the first formation of the ovisac, the eggs being ejected into the sac as it grows; ovisac at completion containing sometimes as many as 350 eggs; ovisac convex above, sometimes irregularly split, more often nearly conical, divided by several regular longitudinal grooves or ribs.

Female of second stage dark-red, elongated, slightly convex, active, covered with thin meal, or short curly cotton. Body hairy with marginal tufts and spinnerets, as in adult. Anal tubercles inconspicuous, but the abdomen exhibits three small lobes on each side, from which spring six short setæ. Antennæ of nine nearly equal joints, hairy. Feet normal, thick. Several radiating, fine, cottony filaments. Length of insect variable, from $\frac{1}{10}$ in. to $\frac{1}{6}$ in. The dorsum exhibits the longitudinal raised ridge, but less conspicuously than in the adult.

Young larva, about $\frac{1}{24}$ in. long, dark-red, elongated, flattish, active; covered with yellow cottony down. Antennæ of six joints, hairy; the last joint is much the largest, clavate, apparently four-ringed, bearing four long hairs. Feet slender; digitules short, fine hairs. Eyes prominent, tubercular. Mentum biarticulate. Anal tubercles represented by three small processes at each side of the abdominal extremity, each process bearing a very long seta. Six longitudinal rows of circular multilocular spinnerets, four on the dorsum and one on each edge. Alternating with these are rows of hairs with tubercular bases.

Adult male large, the length slightly varying; some specimens reach $\frac{1}{8}$ in.; expanse of wings, $\frac{1}{4}$ in.; length of antennæ about $\frac{1}{8}$ in. Body red, with a shining, diamond-shaped, black patch on the dorsal surface of the thorax; legs and antennæ black. Wings dark brown with (in some lights) a bluish tinge, marked with oblique, narrow, wavy stripes; main nervure red, branching once; there are also two longitudinal, whitish, narrow bands.* Antennæ very long and slender, with 10 joints, which may easily be taken for 19, for, after the first, which is short, round, and simple, all the other nine have two dilated portions with a constriction in the middle, and on each dilation is a ring of very long hairs, giving the antenna a feathery appearance.† Eyes very large and prominent, almost pedunculated, brown, divided into numerous semi-globular facets. Feet long and very hairy; coxæ short and thick; tibiæ long and slender; claw thin; upper digitules absent; lower pair only short bristles. Abdomen slender, segments somewhat distinct; on

* Signoret (Ann. de la Soc. Ent. de France, 1875), under the genus *Monophlebus*, speaks of "les plis hyalins" as existing also in the wings of the males of that genus.

† Misled by similar appearances, Burmeister and Westwood assign 25 joints to the male antenna of *Leachia fuscipennis*.

each segment some hairs; the last segment ends in two thick conspicuous cylindrical processes, which, on side view, are seen to incline upwards, and beneath them is the short, conical spike, sheathing the penis. Penis red, longish, tubular, and thick, with many recurved short hairs, and at the end a ring of short spines. Each of the two processes on the last segment bears three or four long setæ, but there do not appear to be any of the long cottony appendages seen in the males of most Coccids.

Habitat.—On wattle, pine, orange, lemon, cypress, rose, gorse, grass, and, in fact, on almost every kind of native and introduced plants, Nelson, Hawke's Bay, Auckland. It will probably appear also elsewhere, but the climate of Canterbury and Otago may prove too cold in winter for it.

Allied to *I. sacchari*, Guérin, which damages sugar-canes in Mauritius; but differing in the formation of the ovisac, the presence of the marginal tufts and spinneret tubes in the female, and in other particulars. The male of *I. sacchari* has not been described. The male of *I. Purchasi* is probably quite distinct.

This species is supposed to have come originally from Australia. It has been very injurious to orange and lemon trees at the Cape of Good Hope and in California. In Auckland it has destroyed whole orchards of the same trees, and in Nelson and Hawke's Bay it is a dreadful pest on all kinds of plants.

The following are references to the plate given on the opposite page:—

Icerya Purchasi.—a, insects on twig of Acacia (Wattle), natural size; *b*, adult female and ovisac, upper view; *c*, adult female and ovisac, side view; *d*, female of second stage; *e*, larva, with yellow cotton; *f*, adult male; *g*, haltere of male; *k*, two joints of male antenna; *m*, hairs, spinnerets, and glassy tubes of female; *n*, antenna of adult female.

The literature of *Icerya Purchasi* is already somewhat extensive.* The most complete and exhaustive account yet published is found in the report, for the year 1886, of Professor Riley, M.A., Ph.D., Entomologist to the U.S. Department of Agriculture, Washington, 1887, pp. 466–492.

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* *Report of the Commission appointed to inquire into . . . . the "Australian Bug."* Cape Colony, 1877.

Journal of Forestry. On the "Australian Bug" of South Africa. May 1882, pp. 41–46.

Insects injurious to Fruits. By William Saunders, F.R.S.C., Philadelphia, 1883 p. 400, with woodcut.

New Zealand Transactions. Vol. xi., 1878, p. 221; vol. xvi., 1883, p. 140; vol. xvii., 1884, p. 30; vol. xix., 1886, p. 45.

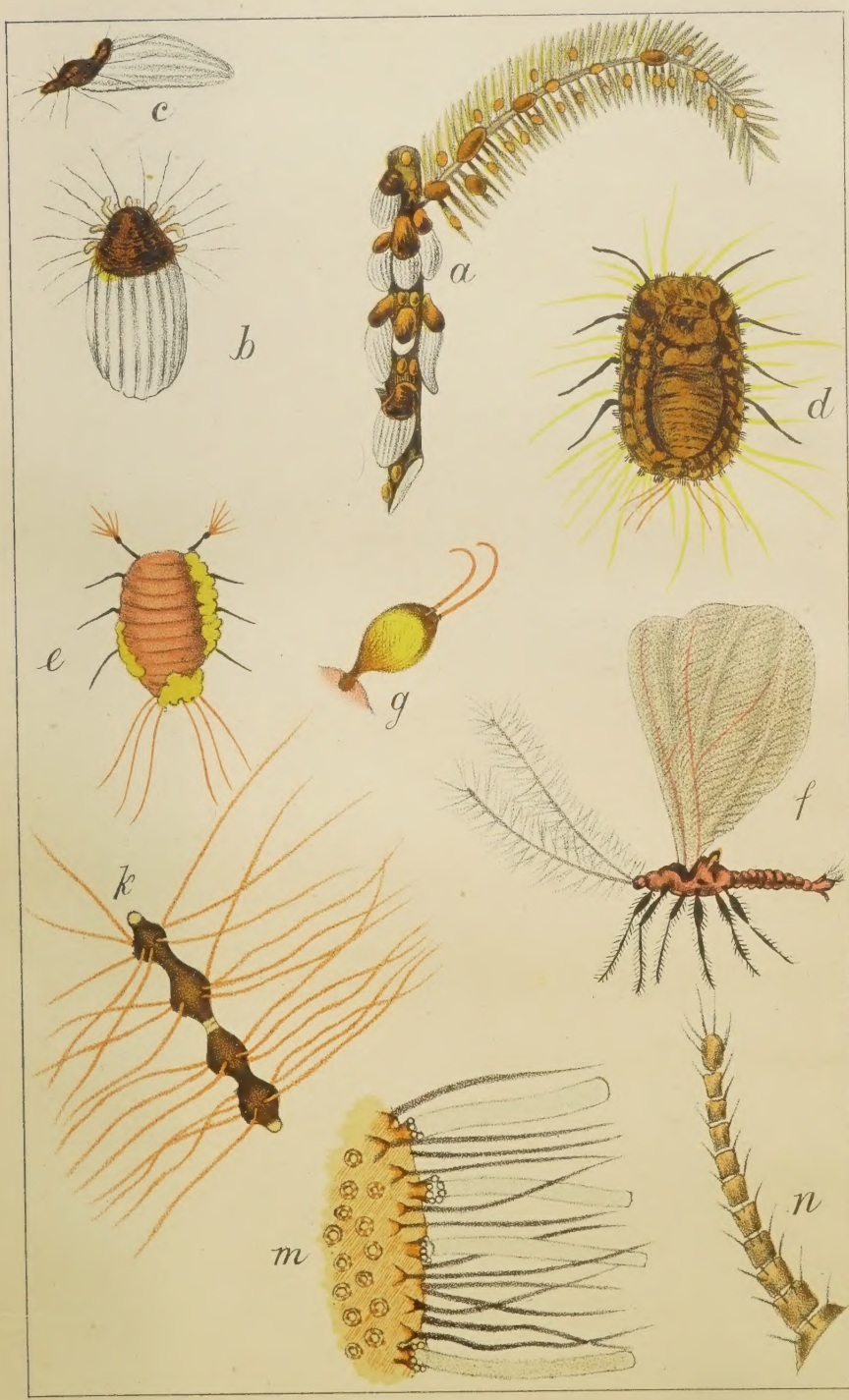
Report of the Entomologist, Charles V. Riley, M.A., Ph.D., for the year 1886 [U.S. Department of Agriculture], pp. 466–492, with plates. Washington, 1887.

The Icerya, or Fluted Scale. Bulletin 15, U.S. Department of Agriculture, Division of Entomology. Washington, 1887.

An Account of the Insects noxious to Agriculture and Plants in New Zealand. The Scale Insects (Coccidæ). By W. M. Maskell, F.R.M.S., Wellington, N.Z., 1887. pp. 104–107, plate xix.

Injurious Farm and Fruit Insects of South Africa. By Eleanor A. Ormerod, F.R.Met.Soc., and O. E. Jansen, F.E.S., London, 1889. pp. 69–98, with woodcuts. (The notes on *Icerya Purchasi* are a reprint, in abridged form, of a pamphlet published in 1887, under title of "Australian Bug of South Africa.")

[Further and more recent information respecting *Icerya Purchasi* is contained in *Insect Life;* a periodical Bulletin of the U.S. Department of Agriculture, Division of Entomology, vol. i., parts 1 to 20. July 1888 to June 1889.]



W.M.M., delt. ad nat.

A.D. WILLIS, WANGANUI, N.Z.

PLATE XIX.

Icerya Purchasi, Maskell.

It would be impossible to curtail this report to any large extent, and as Professor Riley has specially investigated the subject with the view of successfully treating the insect from a horticultural point of view, it is desirable to place as much information as possible within reach of those who would not otherwise be able to obtain it.

The following is Professor Riley's account of *Icerya Purchasi*:—

We have, during the year, been conducting a special investigation of the habits of and remedies for the so-called Cottony Cushion-scale of California, an insect which for the last eight years has occupied much of the attention of the horticulturists of that State. We have been much interested in this pest since it was originally sent to us while in Missouri by Mr. R. H. Stretch from San Francisco in 1872, and have watched its increase and spread, until it became evident from its alarming prolificacy, from the great diversity of its food-plants, from its supposed immunity from the attacks of natural enemies, and from the protection against the action of insecticides afforded by its abundant waxy excretions, that especial study and experiment were much needed.

The following account of the insect is prepared from published accounts and unpublished correspondence; from our biologic notes made at the office in Washington, chiefly in 1878, 1880, and 1886; but more especially from our recent experience in the field (which the delay in publishing the report has enabled us to partly embody), and the observations of Messrs. Coquillett and Koebele, whose reports on experiments made to destroy it will be found given in full among the reports of agents.

Geographical Distribution.

So far as we have been able to learn, up to the date of present writing, the Cottony Cushion-scale is found only in California, in Australia, in South Africa, and in New Zealand. We shall discuss its introduction into California and its present limitations in that State in subsequent sections of this paper, and what we know of its spread in the other countries mentioned is here considered.

In Australia.—As will appear farther on, the evidence collected goes to prove that this insect is indigenous to Australia and has been exported from this colony to the two other colonies in which it occurs and to the United States. We have very few facts as to its occurrence in Australia and these are taken at second hand. We have addressed communications to a number of naturalists in different portions of that country, but their replies have at this writing not been received. From the "Report of the Commission appointed by his Excellency the "Governor to inquire into and report upon the means of exterminating "the insect of the family '*Coccidæ*,' commonly known as the 'Australian "Bug,'" published at Cape Town, 1877, and from the letter of Mr. Roland Trimen, dated February 5, 1877, and published by the Government Secretary of Cape Colony as "Government Notice No. 113, 1877," we find that at that time specimens of the insect were sent from Cape Town to different portions of Australia, and that replies were received as follows:—The Queensland authorities simply promised inquiry and report. The Government of South Australia did not recognise the insect in question as a native of that colony. The inquiry to Victoria was referred to Prof. Frederick McCoy, Director of the National Museum at Melbourne, who identified the insect as a new *Dorthesia*, "common in Victoria on different kinds of *Acacia*."

This is the extent of our information. Mr. Maskell, in his second paper on this species (Transactions and Proceedings New Zealand Institute, XIV., p. 226, 1881), writes: "When in Australia a few "months ago I observed at Ballarat an insect, certainly an *Icerya*, but "I think not *I. Purchasi;* but I had no opportunity of bringing away "a single specimen." There exists, then, a possibility at least that the insect under consideration is found at Ballarat as well as around Melbourne.

In Cape Colony.—We find in the "Report of the Commission," &c., just cited, the following information on the spread of the insect in this colony:—

"From the answers received it would seem that the insect, having first appeared and succeeded in establishing itself in Cape Town and the vicinity, gradually spread along the lines of traffic by land and sea to different parts of the colony; and we may mention, in evidence of its irregular dispersal by chance methods of conveyance, that it was observed in the village of Ookiep, Namaqualand, only a few months after its first discovery in the Cape Town Botanical Gardens in 1873, and yet was not seen in the neighbouring division of Stellenbosch till the latter end of 1876."

The limits to which the insect had extended at the time of the publication of the report of the Commission (1877, presumably the latter part of the year) included the following localities:—Cape Town and neighbourhood, Simon's Town, Stellenbosch (Mulders Vlei), Malmesbury, Paarl, Wellington, Namaqualand (Ookiep), Bredasdorp, George (Brak River), Uitenhage, East London.

We have no information as to the present status of the insect in this colony, as the replies to our letters of inquiry have not yet come to hand.*

In New Zealand.—From the paper containing Mr. Maskell's original description of *Icerya Purchasi* (Trans. and Proc. N.Z. Inst., XI., 220, 1878), we learn that the insect was first noticed at Auckland. A note by Mr. E. A. MacKechnie (Ibid., XIV., 549, 1881) indicated that it had greatly increased in presumably the same neighbourhood in 1881. In Mr. Maskell's second paper (Ibid., p. 226) he mentions in a footnote that he had just received the insect from Napier. In his third paper (Ibid., XVI., 140, 1883) he writes as follows:—

"*Icerya Purchasi* has spread greatly in the last two years. It had just reached Napier at the date of my last paper. It has now established itself in that district not only in gardens, but in the native forests. In Auckland it is attacking all sorts of plants. * * * It has reached Nelson, and I have had many communications from that place complaining of its ravages. * * * Whether this pest will spread in our colder southern climate (Christchurch) as it has in the warmer north remains to be seen. Our gardeners here are not in much dread of outdoor insects; they confine their attention to those in greenhouses. They may be right; still the winter even in Canterbury is not severe enough to kill these insects, and I know that in the Christchurch public gardens many trees have had to be burnt simply on account of the ravages of *Coccidæ*."

We have no information on this point from this colony later than 1883, but have taken steps to ascertain the present spread of the pest.

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* Just as the report is being sent to the printer we learn from Miss Ormerod that she has received specimens from Port Elizabeth, Cape Colony.

Importation of the Species into California.

The first printed record, with which we are acquainted, of the occurrence of the Cottony Cushion-scale in California is Mr. Stretch's article in the Proceedings of the California Academy of Sciences, Vol. IV., read September 16, 1872. In opening this paper he refers to the fact that "at a former meeting certain insects forwarded to this society "from Menlo Park, San Mateo County, by Mr. Gordon," were referred to him for examination. A careful search through the previous proceedings fails to show any mention of this previous sending, though at the meeting of July 1, 1872, Mr. John Hewston, junr., "exhibited "some limbs of Australian Acacia from San Mateo which were infested "by a species of Coccus, and stated that the insect had not only been "detected in its depredations upon said tree, but also upon the orange "trees." This latter reference may very possibly have been to the Cottony Cushion-scale, and if so it is interesting, as indicating already a spread of some miles from Menlo Park.

All the slight evidence possessed points to the introduction of this scale on Australian Acacia by Mr. George Gordon about 1868 or 1869. Mr. Stretch says:—

"This being all the information to be derived from the specimens referred to me, I visited Menlo Park in search of further information, and received a very hearty welcome from Mr. Gordon. The supposition is that the insect was imported from Australia some three years ago; at any rate it seemed to originate on the *Acacia latifolia*."

This was evidently Mr. Gordon's supposition, and the plain inference is that about three years previous to this time certain Acacias had been imported by Mr. Gordon from Australia as plants or cuttings contrary to the general custom, although it is not stated in so many words.

Dr. A. W. Saxe, of Santa Clara, Cal., in 1877, wrote*:—

"So far as I can ascertain, it was brought to California on some plants imported from Australia by the late George Gordon, of Menlo Park (the sugar refiner)."

In the introduction to our annual report as Entomologist to this Department for 1878 we referred to the serious complaints that came from the Pacific coast of injury by it to orchard and ornamental trees, and from specimens received from Dr. Saxe (Mr. Maskell's papers being unknown here then) referred it to the genus *Dorthesia*, and remarked:—

"It is an Australian insect, and has of late years been introduced on Australian plants into South Africa, where, as I learn from one of my correspondents, Mr. Roland Trimen, curator of the South African Museum, it has multiplied at a terrible rate, and become such a scourge as to attract the attention of the Government. It has evidently been introduced (probably on the Blue Gum or *Eucalyptus* (to California, either direct from Australia or from South Africa, and will doubtless become quite a scourge; because most introduced insects are brought over without the natural enemies which keep them in check in their native country and consequently multiply at a prodigious rate. It will be naturally partial to Australian trees, and shows a preference for Acacia, Eucalyptus, Orange, Rose, Privet, and Spiræa."

Professor Comstock, in the annual report of the Department of Agriculture for 1880, p. 348, cited this Article of Dr. Saxe's as the earliest article with which he was acquainted, and repeated Dr. Saxe's opinion as to the introduction of the insect.

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* *California Agriculturist and Artisan*, December 1877.

Beyond this we are able to get no information upon the subject, and these data are in all probability the first connected with the introduction of the Cottony Cushion-scale. There may possibly have been subsequent and independent importations, but that this is the one from which the main spread originated there can be little doubt.

Its Spread and present Limitation in California.

We are indebted to Mr. Matthew Cooke, of Sacramento, for communicating a lengthy and careful account of the localities in which the pest at present exists in California. Mr. Cooke has mapped out ten districts, six in the counties of Marin, San Mateo, Santa Clara, Sacramento, Sonoma, and Napa, in the San Francisco region, and four in the counties of Santa Barbara and Los Angeles, in the southern portion of the State.

The first infested district extends from Menlo Park to San Mateo, a distance of 10 miles. It is bounded on the east by the Southern Pacific Railroad, and extends some 3 miles west, including in consequence some 30 square miles. But little effort, according to Mr. Cooke, has been made to eradicate the pest in this district.

The second infested district is contained within the town limits of San Rafael, Marin County, about 14 miles north of San Francisco. In this district it has been held in check, but there are still some to be found, and its increase is only dependent upon a lapse of vigilance.

The third infested district includes the city of San José and the town of Santa Clara, and contains an area of about 16 square miles. In these towns the scale insects infested the ornamental and shade trees and shrubbery, but did not seem to trouble the deciduous fruit trees to any extent. At San José energetic measures have been taken; the trees have been cut back and their trunks scrubbed until the pest has been thoroughly eradicated. At Santa Clara, however, little has been done, and some places are seriously infested.

The fourth infested district occurs at the city of Sacramento, where only about 120 acres are infested, although it is stated to be rapidly spreading. The insect was first discovered in this district by Mr. Cooke in October 1885, in about eight gardens. The city trustees appropriated $200, and with this sum it was destroyed, except upon certain premises which the authorities could not enter. Mr. Cooke gives in this connection, as an instance of the rapidity of the multiplication and spread of the insect, the following:—

"In October 1885 a patch of these insects covering a space of about 3 by 4 inches was noticed upon a limb of an acacia tree. From these it spread, and in a little more than a year several orange and lemon trees and other plants growing closely in an area of about 160 by 80 feet had become seriously infested."

The fifth infested district is found at Healdsburg, Sonoma County, about 65 miles north by west of San Francisco. Here the insect is mainly comprised within the town limits, and infests the shade trees along the streets and the shrubbery in the gardens.

In Mr. Cooke's sixth district the insect cannot be said to exist at present. It comprises a single garden in the town of Saint Helena, Napa County, about 60 miles north by east of San Francisco. It was found upon a rose bush in that place by Mrs. Richard Wood in October 1882. The bush was destroyed, and the pest has not been found in that section since.

The seventh infested district includes the city of Los Angeles, where the insect is principally confined, according to Mr. Cooke, to the gar-

dens and suburbs on the eastern side of the city. Mr. Coquillett says that as nearly as can be ascertained the insect was first introduced into Los Angeles in 1878 upon some nursery trees purchased from a San Francisco nurseryman. These trees were planted in a certain nursery, and when the insects were first noticed upon them the owner was requested to burn them. He neglected to do this and soon after failed in business, and the nursery fell into other hands. The new owner also proved indifferent, and from this point the insects spread into the surrounding orchards, going mainly in the direction of the prevailing winds. Some years ago a tree was found infested at Passadena, 7 miles east of Los Angeles, but it was immediately destroyed, and the insect has not been heard of since. At Pomona, 32 miles east of Los Angeles, the same thing happened in 1883. Two trees were found to be infested and were immediately destroyed, and the insect has not appeared since.

The eighth infested district is at Anaheim, Los Angeles County, 27 miles south by east of Los Angeles. Here the insect is purely local and does not seem to be spreading.

The ninth district is at San Gabriel, 9 miles east of Los Angeles. In the vicinity of this place are some of the largest orange groves in California. In 1880 or 1881, according to Mr. Cooke, a Mrs. McGregory bought a pot-plant in Los Angeles, brought it home, and placed it beside a small Orange near her house. In 1882 the neighbouring orange trees were found to be infested with the Cottony Cushion-scale. In the fall of 1883 it was found in some of the larger orchards so abundantly as to cause alarm among the growers. By means of a voluntary tax of five cents per tree, some fifteen hundred or two thousand dollars were raised and expended and the pest eradicated. The most radical measures were used. The trees were cut back to the crotches, the branches burned, and the trunks scrubbed. In 1885, however, the insect was again found, but only in a few trees.

The tenth and last district includes the orchards in and around the city of Santa Barbara. According to Mr. Coquillett the scale was introduced into this district in 1878. A number of trees from the same lot which first introduced the pest into Los Angeles was sent to Santa Barbara at about the same time. Mr. Cooke states that he visited this district in July 1884, and found Mr. Stowe's orchards (10 miles north of the city of Santa Barbara) the most seriously infested spot in the State. Forty acres, principally of lemon trees, were badly damaged, and over many acres the trees had been dug out and burned. Two miles north of Mr. Stowe's, Colonel Hollister's groves also contained the insect in numbers. About 40 acres were partially infested. The latter gentleman made strong endeavours to rid his groves of the insect, and spent a great deal of money, with only partial success. Mr. Cooke states that the course of the insect between Mr. Stowe's and Colonel Hollister's could be plainly traced over a rolling grazing land on the nettles, dock, and other weeds.*

* Reports have gained currency that this Icerya was found abundantly around Santa Barbara on wild plants, and especially upon the "Grease-wood," and it has been argued from such reports that the species is indigenous. They have no foundation except in mistaken identity, a large Coccid belonging to the genus *Rhizococcus*, which occurs abundantly on *Artemisia californica*, having undoubtedly given rise to the report. The female of this species, which we shall describe as *Rhizococcus artemisiæ*, secretes a globular mass of white cottony wax, which is more or less distinctly ribbed, and her eggs are of the same color as those of the Icerya; but with these superficial resemblances which have misled, there are profound structural differences.

Food-plants.

Original Food-plant of Icerya Purchasi.—There seems good reason to believe that this species is originally an Acacia insect, and that upon one or another of the plants of this genus it was imported from Australia into South Africa, California, and New Zealand. Australia is pre-eminently the home of the Acacias, while none are indigenous to California, nor, so far as we can ascertain, to New Zealand, and, as is well known, the species now found in these two countries have been introduced from Australia.

Professor McCoy, of Melbourne, in his original communication to the government of Cape Colony, in 1876, stated that the insect in question occurred in Victoria on "different kinds of Acacia."

Mr. J. C. Brown* states, on the basis of Mr. Trimen's description, that the "Australian Bug" appears to resemble in several details one of the Coccidae found on the Kangaroo Island Acacia, universally around Adelaide. This statement is so indefinite as to have little weight; yet there is more than a possibilty that the Australian insect mentioned is the *Icerya*.

Mr. Trimen, in his report previously mentioned, states that the first specimens seen by him in Cape Colony occurred in 1870, at Clairmont, on Blackwood trees (*Acacia melanoxylon*), obtained from the botanic gardens at Cape Town. He goes on to say:—

"In the course of a few months the insect increased so prodigiously in number, and the Australian Acacias became laden with them to such an extent, that in the early part of 1874 the large Blackwood trees in the gardens, which were infested to a greater extent than any other plant, had to be cut down."

In New Zealand the first appearance of this insect was also upon an Australian Acacia. Mr. Maskell, in originally describing the insect, in 1878, says: "My specimens of this subdivision were found on a hedge "of the Kangaroo Acacia,† in Auckland, in March last. I understood "from Mr. Cheeseman and Dr. Purchas, who kindly brought this insect "under my notice, that it had only lately appeared in Auckland, and "that it was only as yet to be found upon that one hedge."

In California the experience was almost precisely similar. Mr. Stretch, in his paper before the California Academy of Sciences, in 1872, stated that at Menlo Park "it seemed to originate upon *Acacia latifolia*, a "species imported from Australia." Miss Anna Rosecrans, writing to the *Pacific Rural Press* of February 17, 1877, says: "It was first "noticed at San Rafael on Acacia trees four or five years ago." Dr. Chapin, in the first report of the State Board of Horticultural Commissioners of California, 1882, says: "This scale has been, it is asserted, "known to be on the Acacia for seven years in San José, but it is only "during the past and present seasons that it has attracted attention" (presumably by its spread to other cultivated plants).

Thus we have much cumulative evidence that the species of the genus Acacia are the preferred food-plants of the Cottony Cushion-scale, and, admitting Australia as its proper home, they are probably its original food.

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* On the "Australian Bug" of South Africa. *Journal of Forestry*, May, 1882, VI., p. 44.

† *Acacia armata*.—C. V. R.

Its Food-plants in South Africa.—From Mr. Trimen's 1877 report we gather the following list of plants to which the Australian Bug had spread since 1873 :—

Acacia melanoxylon, Australian Acacias, "Golden Willow," *Casuarina*, *Pittosporum*, "Blue Gum" (rarely), Australian "Bottle-brush," Oak, Orange, Vine, Fig, *Laurustinus*, Rose, Rosemary, Strawberry, Verbena, Plumbago, Indian Jasmine, *Bougainvillea*, Hawthorn, *Poinsettia*, *Hakea*.

This list is not added to in the "Report of the Commission," &c., published at Cape Colony in 1877. Mr. Trimen, in the article cited above, gave the preference to the trees and shrubs of Australian origin; but Mr. J. C. Brown (*loc. cit.*) quotes him as writing, under date of March 17 (1882 ?), that the insect had then mainly attached itself to the orange trees. "Many of the finest plantations have been destroyed and "others are on the high road to destruction. You will remember," he says, "how good and cheap oranges used to be here; they have lately "been threepence and fourpence apiece, and often inferior in quality "even at such a price."

Its Food-plants in New Zealand.—From the various communications of Mr. Maskell and others in the Transactions and Proceedings of the New Zealand Institute we give the following list of plants which have been especially designated. There has been no attempt, however, on Mr. Maskell's part to give at all a complete list, and in fact, he says,* "In Auckland it is attacking *all sorts* of plants, from Apple and Rose "trees to Pines, Cypress, and Gorse." The plants affected are—

Common Furze, Orange, Lemon, *Acacia decurrens*, *Acacia armata*, Apple, Wattles, Rose, Gorse, Pine Cypress.

Its Food-plants in California.—Originally starting upon *Acacia latifolia* at Menlo Park, this insect soon spread to numberless other plants. Dr. Saxe in 1877 mentioned that it already attacked the Acacias, Australian Pea-vine, Rose, Honeysuckle, Ivy geranium, Laburnum, Pear, and the weeds in the orchard.

Dr. Chapin, in 1883, mentioned the following:

Pear, Apple, Bridal-wreath, Rose, Dwarf Box, Verbena, Veronica, *Acacia mollissima*, *Acacia latifolia*, *Acacia linnearis*, *Acacia floribunda*, *Pittosporum tobira*, Strawberry, Black Locust, California Laurel, Cork Elm, English Ivy, *Magnolia grandiflora*, White Oak, Dwarf Flowering Almond, Wild Grease-Wood.

Our recent experience in California, as well as that of Messrs. Coquillett and Koebele last summer, would indicate that, while there are few plants upon which the insect will not temporarily feed if it happen to fall upon them while in the first stage, yet the number of plants upon which it can thrive and multiply is limited. The larva will survive for weeks without food and will wander about in search of suitable food if it should find itself, for one cause or another, on that which is unsuitable. It undoubtedly thrives best on Acacias, and next to these we should place the Citrus fruits, the Quince, and the Pomegranate, and we doubt if it could thrive upon many other trees. The list of its food-plants, or rather of plants upon which it has been found, is longer than is justified, not only because of its power of endurance above noted, but because the young are easily carried by wind or otherwise to plants more or less uncongenial and on which they ultimately perish, while the adults are often dislodged from infested Acacia or Citrus trees on to plants under or near them.

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* Ibid., XVI., p. 140 (1883).

Among the more valuable trees upon which it certainly cannot thrive, and upon which it does not occur when they are grown at some distance from infested Acacia or Citrus trees, are the following: Pines, Cypress, Eucalyptus, Olive, Apricot, Peach, Pear, and Oleander.

The plants upon which Mr. Coquillett found females with egg-masses in limited numbers, and which were growing in situations so remote from any infested Acacia or Citrus trees as to preclude the idea that the adult insects had found their way to these plants from such trees, were as follows:—

Pomegranate, Quince, Apple, Peach, Apricot, Fig, Walnut, Locust, Willow, Pepper, Grape, Rose, Castor-bean, Spearmint, Rose-geranium.

Mr. Koebele, whose observations have been close and extensive, found that the Quince is always thickly infested, as is also the Pomegranate, while on Pear, Apple, Peach, and Apricot the scales were not numerous in the adult state. Only a few scales, and these nearly always small, were found upon the Castor-oil bean. Some Pecan trees were noticed on which some of the branches were completely covered with scales. A Willow hedge surrounded by plants which had been infested for over two years did not itself become attacked until the past summer. The Fig he states to be a favourite food-plant. On Eucalyptus he found young scales all summer, and in October he found twigs full of scales of all sizes. A few full-grown individuals were found upon a single Pepper tree (*Schinus molle*) growing in the orchard. The following is a supplementary list of plants upon which Mr. Koebele reported the scales most noticeable:—

Portulaca oleracea—scales often numerous, *Malva rotundifolia*, Grape (*Vitis* spp.)—scales occurring principally on petiole and leaf, *Medicago denticulata*, *Helianthus* spp., Rose (*Rosa* spp.)—scales growing often to an unusually large size, and very numerous on some varieties, *Epilobium coloratum*, *Erigeron canadensis*, *Bidens pilosa*, *Artemisia ludoviciana*, *Ambrosia psilostachya*—hundreds of scales on each plant during July, August, and September, *Sonchus oleraceus*, *Plantago* spp., *Mentha piperita*, *Stachys æquata*, *Solanum tuberosum*, *Solanum Douglasii*, *Chenopodium murale*, *Chenopodium album*, *Amarantus retroflexus*, *Polygonum persicaria*—stem often entirely covered by scales, *Rumex crispus*, *Urtica holosericea*—a favourite plant, on which the scales developed with unusual rapidity and to large size, *Carex* spp., *Paspalum* spp., *Panicum crus-galli*.

Characters and Life History.

The genus *Icerya* was first described by Signoret in the "Annales de la Société Entomologique de France" for 1875, pp. 351, 352, and was founded on the single species *I. sacchari* (Guérin), which occurs on sugar cane at the Island of Bourbon. He knew only two stages, the full-grown female and the newly-hatched larva, but these were described with his customary care.

Mr. Maskell, in describing the species under consideration, places it without much hesitation in this genus, and later, in 1883, still places it in *Icerya*, after examining specimens of *I. sacchari* sent him by M. Signoret. In his original paper (Trans. Proc. N.Z. Inst., 1878, 220), Mr. Maskell describes quite carefully the egg, the young larva, the second stage, and the full-grown female, but had not seen the male lava, cocoon, or adult. Professor Comstock (Ann. Rept. Dept. of Agric., 1880, p. 347) follows Maskell's description quite closely, and introduces no new facts.

There is therefore a necessity for a careful review of the complete life history of the insect, and this we have endeavoured to give in the following pages.

The Egg.—The egg is quite smooth, elongate-ovate in form, and is of a deep orange-yellow colour. It measures about 0·7^{mm} in length.

The average number of eggs laid by the females varies according to the vigour of the individual or the condition of the plant upon which she dwells; prolificacy diminishing in proportion as the plant is badly infested—a general law among Coccidæ. Over 800 eggs have been counted in a single egg-mass by Mr. Coquillett, while Mr. Koebele has counted in a single egg-mass, which, by the way, was found upon nettle (*Urtica holosericea*), 940 eggs and 72 young larvæ, while 123 eggs yet remained in the dead body of the female, making a total of 1,135 eggs from the single female.

The time required for the eggs to hatch after leaving the body of the female varies with the temperature. In the winter time the sacs are usually filled with eggs, while in the hottest part of the summer seldom more than one or two dozen will be found in each sac. Some collected by Mr. Coquillett on the 18th of March did not hatch until the 10th of May; but in mid-summer hatching is only a matter of a few days.

The female Larva — First Stage. — The newly-hatched female larva (and probably the male is identical with it at this stage of growth, since we have not been able to separate them into males and females) is red in colour, inclining somewhat to brown. The body is ovoid in outline, being flattened beneath and convex above. The antennæ are long and 6-jointed. Joint 1 is short and stout, and as broad as long; joints 2, 3, 4, and 5 subcylindrical and subequal, much more slender than joint 1, and twice as long as broad; joint 6 is as long as 4 and 5 together, and forms a long club, at base equalling joint 5 in diameter, but broadening out to twice its width at tip. The basal portion of the club is sometimes distinctly separate from the rest, forming an additional joint. All joints have a few sparse hairs, and the club, in addition to several short ones, bears near its tip four very long ones, each of which is considerably longer than the whole antenna. The legs are thin and brown in colour. The coxæ and femora are moderately large, while the tibiæ and tarsi are long and thin, the terminal joints of the latter bearing several long hairs. The upper digitules are represented by simple hairs, but the lower ones are present and are bent near the base. The eyes are prominent and are each mounted on a short tubercle. The mentum is broad and apparently 2-jointed. The rostrum is broad at base and the rostral setæ are not very long. At the tip of the rounded abdomen are 6 small tubercles, 3 each side of tip, each of which carries a long stout hair, which is as long as the whole body. The body above shows 6 rows of secretory pores, 4 along the middle, and 1 on each side. More or less regular rows of hairs alternate with these pores.

Female Larva—Second Stage.—According to Maskell and Comstock, there are but three stages of growth in the female after hatching, and these are readily distinguished by the number of antennal joints; the larva of the first stage having 6, that of the second 9, and the adult 11. Messrs. Coquillett and Koebele came to the same conclusions, and all have overlooked a form which we have found quite abundantly among the material we have studied, and which seems to constitute an intermediate stage between the so-called first and second, and which is of course produced by an additional molt which we have personally observed in the field. Hence the so-called "second stage" of these authors

becomes third, while the adult female is fourth instead of third, and there are 3 moults instead of 2.

This new intermediate form differs from the female larva of the first stage in the following respects: It is much more rounded and of a stouter general appearance. The antennæ have the same number of joints, 6, but their relative proportions are quite different. The antennæ as a whole are relatively much shorter. Joint 1 is short and stout, its length equalling its breadth; joint 2 equals joint 1 in length, but is not quite so broad; joint 3 is as broad as joint 2, but is twice as long; joints are 4 and 5 are equal in length and width, each narrowing somewhat at base and tip, each considerably narrower than joint 3, and each of the same length as joint 2; joint 6 (club) is of an irregular shape; at base it is as narrow as joint 5, but it broadens until it is slightly wider than 2 or 3, and its tip is narrowed again; its shape is that of an irregular rhomboid with rounded angles and sides, the acutest angles at base and tip. The antennæ carry about the same number of hairs as in the first stage, but those homologous with the four very long hairs of the club in that stage are in this second stage but little longer than the other antennal hairs. The eyes do not appear on the margin of the body, and are only seen on a ventral view. The legs are proportionately much shorter, and the femora are stouter; the trochanters are broader distally, and consequently form a broader triangle in shape. The six tubercles at the anal end of the body are still present, but the hairs which they bear are much shorter. The secretory pores are no longer arranged in rows, but are scattered sparsely over the back and under the sides. The back is more hairy, and the short black hairs occur in irregular tufts.

Female Larva—Third Stage.—That which has heretofore been considered the second stage, and which, as we have just seen, is the third, may be described as follows:

The body is broadly oval in shape and reddish-brown in colour, but is soon obscured more or less by the thick, curly, cotton-like excretion. The antennæ are 9-jointed instead of 6, and are subcylindrical, tapering somewhat from base to tip. Joints 4, 5, 6, 7, and 8 are subequal in length, and each is about as long as broad; joints 2 and 3 are broader and considerably longer; joint 1 is like the corresponding joint in the previous stage; joint 9 (club) is a suboval joint, proportionately much smaller than in the previous stages; it does not exceed joint 8 in width, and it does not quite equal joints 7 and 8 together in length. The long hairs of the club are proportionately quite short. The insect as a whole is much more hairy than in either of the previous stages. The hairs are short and black, and show a marked tendency to grow together in tufts; even when their bases are well separated their tips turn toward each other or toward the common centre of a group; they are quite thickly scattered over the thorax, but less so over the abdomen; all around the edge of the body they appear in close tufts, and the concentric subdorsal ring of tufts which is so prominent in the next stage is plainly seen in this. The secretory pores are scattered irregularly all over the back, and are more numerous than in the previous stage; they also occur under the lateral edges of the body. They are small and circular, and, seen directly from above, have a double outline, indicating a circular central orifice. Around the edge of the body is a row of much larger pores, brown in colour, which protrude from the body, masked by the lateral tufts of hair, each with a circular crown or lip at tip, from which proceeds a long, fragile, glassy tube. The legs and feet are a little stouter than before, the tarsal digitules are shorter, and their enlarged tips quite indistinct. The six anal hairs are still

present, though hardly noticeable as they protrude from the mass of shorter hairs.

The Adult Female—Fourth Stage.—Immediately after the molt by which the insect passes into this stage, it is free from the waxy excretion and presents a broadly oval form, flattened below and quite strongly convex above, with two prominent raised surfaces on the second and third thoracic segments. Its colour is still reddish-brown, with several darker spots, especially upon the front half and along the sides of the posterior half of the body, and the antennæ and legs are black. The antennæ are now 11-jointed instead of 9; joint 1 is nearly twice as wide as long; joints 2 and 3 are subequal in length and thickness and are each somewhat longer than broad; joint 4 is a little more than half as long as 3 and is narrower; joints 5, 6, 7, 8, 9, and 10 increase gradually and slightly in length and decrease very slightly in width; joint 11 (club) is irregularly ovoid and is one and one-half times as long as 10; the special hairs are a little shorter than in the previous stage. The whole body is furnished with short black hairs, more numerous than in the last stage, arranged in tufts, particularly around the edge, where they occur in a double parallel row, the inner row being practically subdorsal and accentuated by a slight ridge. Down the central portion of the dorsum of the abdomen the segments are indicated by the transverse rows of hair tufts. The secretory pores are exceedingly abundant, occurring in enormous numbers just under the lateral edges of the body, and scattered more sparsely over the back. The individual wax filaments which issue from these pores are very delicate and curly, and there is reason to suppose that two or three issue at one time from one pore, as they are frequently seen connected at base; the pore opening, however, seems to have a single simple opening. The inner row of tufts on the back is broken at its anal point by a depression, in which is situated a very large pore, from which the insect occasionally ejects a globule of a semi-liquid honey-dew. This depression is surrounded by an irregular ring of hairs, which are yellowish in colour instead of black. The glassy filaments arising from the large tubular pores described in the last stage are now very long and radiate from the body in almost every direction. They break off easily, yet still often reach a length double that of the insect and her egg-sac together. What is probably the opening of the oviducts is situated on the under side of the seventh abdominal segment. It is surrounded by a transversely oval chitinous ring.

The Egg-sac.—As the body of the female begins to swell from the eggs forming inside, the beginning of the egg-sac is made. The female lies flat on the bark, the edges of the body turned slightly upwards, and the waxy material of which the sac is composed begins to issue from countless pores on the under side of the body, but more especially along the sides below. As the secretion advances the body is raised, the cephalic end being still attached, until, near the completion of the sac, the insect is apparently standing on its head, nearly at right angles to the surface to which it is attached. The egg-laying commences as soon as a thin layer of the secretion has formed on the under side of the abdomen, and it continues during the formation of the sac. There soon appears around the edge of the abdomen a narrow ring of white felt-like wax, which is divided into a number of flutings. These flutings grow in length and the mass of eggs and wax under them increases, forcing the female upward until the sac is completed. When completed, it is from two to two and one-half times the length of the female's body. It is of a snow-white colour, and the outside is covered with 15 of these longitudinal ridges or flutings, of subequal size, except that the middle

one is smaller than the others. The upper part of the sac is firm in texture, but the lower is looser and thinner, and from the middle of the under side the young make their escape soon after hatching. The size of the sac and the length of time required in its growth depends, leaving the weather and the health of the food-plant out of consideration, upon the number of eggs which the female deposits. So long as oviposition continues, the secretion of wax accompanies it and the egg-mass grows. Concerning the rate of growth Mr. Coquillett gives the following instance:—

"On the 4th of May of the present season I marked a large number of females which were located upon the trunk of an orange tree that was not in a very healthy condition. These females had just begun to secrete the cottony matter, the latter at this date being in the form of short but broad tufts around the margin of the abdomen, those at the hind end of the latter being longest. By the 31st of May the cottony matter was equal in length to one-third of the female's body, and by the middle of July it about equalled in length the entire body of the female. As the egg-masses of some of the females upon the same tree were longer by one-half than the bodies of the females which produced them, it is very probable that at least another month must elapse before the egg-masses of the females which I observed would be completed. It is altogether likely, however, that these egg-masses would have been completed in a shorter time had the females been located upon a healthy tree. The egg-masses found upon healthy trees attain larger size than those found upon sickly trees, owing doubtless to the fact that the females living upon trees of the former kind are more vigorous than those upon unhealthy trees."

The Male Larva—probable Second Stage.—Neither Mr. Coquillett nor Mr. Koebele were able to distinguish the male larvæ until these had reached the stage in which they form their cocoons. Among the specimens studied at the Department, and which were sent alive from Los Angeles by Mr. Koebele, we have found a larval form which has not yet been described, and which we strongly suspect may be the male in the second stage. * * * * It differs from our supposed second stage of the female in its more slender form, longer and stouter legs, and longer and stouter antennæ. The legs and antennæ are not only relatively longer and stouter, but are absolutely so. The body above is much more thickly clothed with the short stout hairs than the corresponding female stage, and the mentum is longer and darker coloured. The antennæ are 6-jointed, and the joints have precisely the same strange relative proportions as in the female. The secretory pores are present, but are not quite so numerous as in the female.

Male Larva—Third Stage.—In this, the third or last larval stage, the male is readily distinguished with the naked eye from the female in any stage by the narrower, more elongate, more flattened, and evenly convex form of his body, as well as by his greater activity in crawling about the trunk or branches of a tree. More careful examination shows that the beak is entirely wanting, the tubercle from which it arises in the earlier stages being replaced by a shallow triangular depression. The body is almost naked, being very sparsely covered with a short, white, cottony matter, and is destitute of the short but stout black hairs which are found upon the body of the female during the third and fourth stages of her life. In the absence of black spots and in the 9-jointed antennæ he agrees with the similar or third stage of the female, and the average length when full grown is about 3^{mm} and diameter about 1^{mm}.

The Male Pupa and Cocoon.—When the male larva has reached full growth and is ready to transform it wanders about in search of a

place of concealment, finally secreting itself under a bit of projecting bark, under some leaves in the crotch of the tree, or even wedging itself down under a mass of females. Very frequently, probably in the majority of cases, it descends to the ground, and hides under a clod of earth or works its way into some crack in the ground. Having concealed itself it becomes quiescent, and the delicate flossy substance of which the cocoon is formed begins to exude abundantly from the body. This material is waxy in its character, but is lighter and more flossy and less adhesive than that of which the egg-sac of the female is composed. After a certain amount has been exuded the larva moves backwards very slowly, the exudation continuing until the mass is from 7^{mm} to 10^{mm} in length. From this method of retrogression it happens that the body of the larva is frequently seen protruding posteriorly from the mass, which naturally leads to the erroneous conclusion that the material is secreted more abundantly from the fore part of the body, whereas the reverse is the case. When the mass has reached the proper length the larva casts its skin, which remains in the hind end of the cocoon, and pushes itself forward into the middle of the cocoon.

The pupa has the same general colour as the larva, the antennæ, legs, and wing-pads being paler and the eyes dark. It has also the same general form and size. All the members are free and slightly movable, so that they vary in position, though ordinarily the antennæ are pressed close to the side, reaching to basal part of metathorax (ventrally); the wing-pads also against the side, elongate-ovate in form and reaching to second abdominal joint. The legs are rather shorter than the diameter of body, and the front pair thrust forward. The anal end is deeply excavated, the abdominal joints well separated, the mesonotum well developed, and the pronotum tuberculous or with some eight prominences; but there are no other structural peculiarities. The surface is, however, more or less thickly covered with waxy filaments, which are sometimes exuded in sufficient quantities to give quite a mealy appearance.

Whenever the pupæ are taken from the cocoon and placed naked in a tin box they exude a certain amount of wax, often enough to partially hide them from view. If disturbed they twist and bend their bodies quite vigorously.

The cocoon is of an irregular elongate shape, appearing a little denser in the centre, where the pupa has placed itself, and at the edges delicate and translucent. The material of which the cocoon is composed is very delicate, and appears like the finest cotton, but on submission to a gentle heat it melts as readily as the coarser secretion of the female, and leaves the larva or pupa, as the case may be, clean and exposed.

The adult Male.—A careful description of the male of this species has never been published. It was unknown to Mr. Maskell at the date of his first paper and has not been mentioned in any of his subsequent papers. Mr. Trimen attempted to breed it, but was unsuccessful. He says: "So little is certainly known of the males of the Coccidæ that I "have kept from time to time a large number of this Dorthesia under "glass in the hope of obtaining the males, but hitherto without success. "I once, however, found on my window a male of some Coccus which "I thought was very probably that of the introduced species, as it "agreed in most of its important characters with Westwood's figure of "the male *Dorthesia characias*. It was dark red, with the wings gray, "and very slender and fragile in its structure. It measured $\frac{1}{4}\frac{5}{8}$ inch "across the expanded wings."

The male was unknown to Professor Comstock, but was very briefly

mentioned by Dr. Chapin in the first report of the Board of State Horticultural Commissioners, Sacramento, 1882, p. 68. He found the male in numbers during a period of two weeks from September 25, 1881, but did not observe it in 1882. It is also mentioned by Matthew Cooke in his "Injurious Insects," &c., 1883, p. 166, and a rough and uncharacteristic figure is given at Fig. 146, Plate 3. His few words of description are: "Male insect, winged; colour, thorax and body dark "brown; abdomen, red; antennæ, dark coloured, with light hairs "extending from each joint; wings, brown, iridescent." The following detailed description is drawn up from numerous specimens, both mounted and living:—

"The adult male is a trifle over 3^{mm} in length, and has an average wing expanse of $7 \cdot 5^{mm}$. The general colour is orange red. The head above is triangular in shape, with the apex blunt and projecting forward between the bases of the antennæ. The eyes are placed at the other apices of the triangle, and are large, prominent, and furnished with well marked facets. There are no mouth parts, but on the under side of the head is a stellate black spot with five prongs, one projecting forward on the conical lengthening of the head, one on each side to a point just anterior to the eyes and just posterior to the bases of the antennæ, and the remaining two extending laterally backwards behind the eyes. The antennæ are light brown in colour, and are composed of ten joints. Joint 1 is stout, almost globular, and nearly as broad as long; joint 2 is half as broad as 1 and is somewhat longer; joint 3 is nearly twice as long as 1 and slightly narrower than 2; joints 4, 5, 6, 7, 8, 9, and 10 are all of about the same length as joint 3, and grow successively a little more slender; each joint, except joint 1, is furnished with two whorls of long light-brown hairs, one near base and the other near tip; each joint is somewhat constricted between its two whorls, joint 2 less so than the others. There are no visible ocelli. The pronotum has two wavy subdorsal longitudinal black lines, and the mesonotum is nearly all black, except an oval patch on the scutum. The metanotal spiracles are black, and there is a transverse crescent-shaped black mark, with a short medium backward prolongation. The mesosternum is black. The legs are also nearly black and quite thickly furnished with short hairs. The wings are smoky black, and are covered with rounded wavy elevations, making a reticulate surface, a cross section of which would appear crenulate. The costa is thick and brown above the subcostal vein, which reaches costa at a trifle more than four-fifths the length of the wing. The only other vein (the median) is given off at about one sixth the length of the wing, and extends out into the disc a little more than one half the wing length. There are, in addition, two white lines, one extending out from the fork of the subcostal and the median nearly straight to the tip of the wing, and one from the base in a gradual curve to a point some distance below the tip. Near the base of the wing below is a small ear-shaped prolongation, folded slightly on itself, making a sort of pocket. The halteres are foliate, and furnished at tip with two hooks, which fit into the folded projection at base of wings. The abdomen is slightly hairy, with the joints well marked, and is furnished at tip with two strong projections, each of which bears at tip four long hairs and a few shorter ones. When the insect is at rest the wings lie flat upon the back."

Rate of Growth of the different Stages.

The rate of growth of the insect necessarily depends so much upon surrounding conditions, and especially on the mean temperature, that

it is difficult to make any definite statements as to time elapsing between molts or that required for other periods of the insect's growth. No facts have hitherto been published which bear upon this point. Mr. Coquillett's observations show that individuals hatched from eggs on the 4th of March cast the first skin on the 23rd of April, and underwent the last moult on the 23rd of May. Mr. Koebele also reports a case which bears upon this point, and which is interesting as occurring later in the season. He placed four newly-hatched larvæ on a healthy young orange tree, out of doors, August 5. On September 26 two of them passed through the first moult. October 10 one more moulted, and on October 23 the fourth cast its first skin. All left the leaves after moulting and settled on young twigs. None of them had gone through the last moult when he left Los Angeles, November 6. He was afterwards informed by Mr. Alexander Craw, of Los Angeles, that nearly all of the insects were full grown in February, and he therefore concluded that the individuals observed by him would not attain full growth before that time.

The mature male larva requires on an average about 10 days from the time it begins to form the cocoon before assuming the pupa state, and the pupa state lasts from two to three weeks. The more reliable information we have been able to obtain would show that at Los Angeles the average number of generations each year is three.

Habits.

The newly-hatched larvæ settle upon the leaves and tender twigs, insert their beaks, and imbibe the sap. On passing into the third stage they seem to prefer to settle upon the smaller twigs, although a few are found upon the leaves and still fewer upon the larger branches and trunk. The adults, however, almost invariably prefer the trunk and largest branches.

The insect is rarely found in any of its stages upon the fruit.

The species differs markedly from most Coccidæ in being active during the greater part of its life, though most of the travelling is done by the female immediately after the third molt and by the male just before settling to make his cocoon. At these periods they wander up and down the trunk and larger limbs until they find some suitable place, when they settle down, the male to pupate and the female to insert her beak and develop her eggs and their characteristic waxy covering. She is capable of slow motion even after oviposition has commenced, but rarely does move unless from some exceptional cause. In thus settling after their last wanderings both sexes are fond of shelter and will get under any projecting piece of bark or under bandages placed around the tree, the male often creeping under clods of earth. Both the female and the male, in adolescence, are most active during the hotter parts of the day and remain stationary at night; but the perfect or winged male is rather sluggish during the day, usually remaining motionless on the under side of the leaves of low plants or high trees, in crevices of the bark, or wedged in between females on the tree. There seems, in fact, to be a well-marked attempt at concealment. The recently developed individuals are found abundantly on or under clods of earth near their pupal cocoons, and they issue most numerously during the latter part of the afternoon. They are at first weak, awkward, and ungainly, and instinctively seek some projection on the tree or elevation on the ground from which to launch on the wing.

At the approach of night they become imbued with a very high degree of activity and dart rapidly about on the wing. At such times

they swarm around the infested trees, and many of the females, even some with large egg-masses, hold their bodies raised obliquely from the bark, as though aware of the presence of the males. In September and October Mr. Koebele noticed that the males began their flight about 5 o'clock, and as soon as it was fairly dark they again settled down to rest. None have been observed flying at night and none have been attracted to the electric lights.

Exudation of the Honey-dew.

It required but a few hours upon our first visit to Los Angeles, the latter part of March, to become familiar with the insect in all its habits and conditions, as at that season the species is to be found in all conditions from the egg through all the stages of both sexes. But the characteristic of this remarkable insect which most obviously attracted our attention and distinguished it from all other species of the family, even where there were no gravid females with the fluted cushion, was the saccharine exudation. As with most Aphids and Coccids, this sweet liquid is exuded at all stages of growth, but is most copious from the adult female just before oviposition begins. It is expelled with considerable force from the large pore already described, and in hot weather with sufficient rapidity to produce all the effects of honey-dew. Usually it is limpid enough to soak and discolour the trunk and to drop as it accumulates from the leaves, sometimes being so copious as to remind one of a shower; but at other times, and especially during dry weather, the sugar condenses and forms large drops or masses of white, semi-opaque, sirupy liquid, which adheres to and often completely covers the insect, so that the trunk of the tree looks much as if it had been bespattered with caustic potash or melted stearine. At other times the liquid parts evaporate entirely and leave masses of pure white powdery sugar.

Honey-loving insects seek this sugary secretion in numbers, and it is always followed by the black mold or smut (*Capnodium citri*), which is so universal an accompaniment of all honey-secreting Homoptera, living as it does on the saccharine deposit. The secretion being so very copious from Icerya, the smut is equally thick and copious in her wake. Indeed, the great prevalence of this smut in the Icerya-infested groves of California (rendering it necessary to wash or cleanse the gathered fruit) is as characteristic of the Pacific coast as the rusty effect of the Rust-mite (which is unknown there) is of the orange groves of Florida.

Mode of Spread and Distribution.

The spread of this species will be aided by very much the same agencies that affect the spread and dissemination of other species of scale-insects. We have already, in 1868, in treating of the Oyster-shell Bark-louse of the Apple,* and again four years later,† discussed the principal methods by which such spread is promoted, viz., by the agency of wind and running water; by the young being carried upon birds and other animals, particularly flying insects frequenting the same trees; but primarily by transport upon scions and nursery stock.

In insects like the Coccidæ, where the locomotive power is confined for the most part to a few days in early larval life, the species would be very much restricted in range, and would never pass from one country

* First Report Insects of Missouri, p. 15.
† Fifth Report Insects of Missouri, pp. 85, 86.

to another, except by some of the agencies above indicated. Our observations since we first wrote upon this subject, as well as the extended observations of Mr. Hubbard in Florida, and given in the special report on Insects affecting the Orange, as also Mr. Coquillett's observations on the distribution of the particular species in question, all go to confirm the potency of these means of distribution. Thus Mr. Hubbard found that lady-birds (Coccinellidæ), and more particularly gossamer spiders, are active agencies in such distribution. The agency of the wind, as indicated by the more rapid spreading in the direction of prevailing winds, has often been verified. Mr. Coquillett reports; "In the infested "part of this city (Los Angeles) is a large vineyard, and on both the "north and south sides of it is an orange orchard infested by these "insects; but, while the recently-hatched insects occur on the vines as "far out as the tenth row of grape vines on the south side of the vine-"yard, they are not found upon the vines beyond the third row on the "north side, the wind, as stated above, blowing from the south-west. "No adult females are to be found on any part of this vineyard, and "the young insects must have been carried by the wind from the "infested orange trees on either side of the vineyard." Our own experience in California showed that similar evidence of the influence of the prevailing wind in promoting the spread of the species is general.

While Mr. Hubbard's observations show that the action of the wind is indirect rather than direct, by influencing the flight of winged insects and the floating of spiders which transport the scale-insects, yet we have every reason to believe that winds have a much more direct influence than is generally supposed, especially in the case of severe storms passing over infested districts at the right season. We laid emphasis on this in our earlier writings, and Mr. Coquillett, while admitting the influence of birds, insects, and water in the transportation of our *Icerya*, lays greatest stress upon the direct agency of the wind. Young scale-insects are not easily dislodged, but where a tree is badly infested there is every reason to believe that they instinctively drop from the terminal twigs, and their specific gravity is so slight, that they may be carried long distances in strong wind currents.

In regard to the influence of birds upon the spread of the Cottony Cushion-scale, Mr. Coquillett observed that whenever the nest of a bird is found upon a tree recently infested with this insect, the latter will be found to be most numerous in the immediate vicinity of the nest, thus indicating that the young had been accidentally brought there and in considerable numbers by the old birds. There is no doubt also that the irrigating ditches have a very marked influence on the spread of the species, as many of the ditches pass under infested trees, and the waxy secretion serves both to protect the insect from the water and to facilitate floating.

While, therefore, the gradual spread from orchard to orchard is in the main through the agency of other flying insects and gossamer spiders, yet the transportation of the pests to long distances must necessarily be effected through the agency of high winds, birds and man in commercial intercourse, the latter being probably the only means by which the species have been introduced from one country to another separated by wide ocean areas.

Natural Enemies.

Birds.—The natural enemies of the Cottony Cushion-scale seem to be very few in number, not only in California but also in South Africa and New Zealand. In South Africa the only bird which is recorded as

feeding upon this scale is the common "White Eye" (*Zosterops capensis*), and this is given by Mr. Trimen upon hearsay evidence only: "I have not noticed any of our small birds attacking the *Dorthesia*, "but Mr. C. B. Elliott tells me that his boys have observed the little "'White Eye' * * * pecking at them." From what we have been able to learn of the habits of this bird, however, we are inclined to think that it is attracted rather by the abundant secretion of honey-dew and the minute insects caught in it than by the scale-insects themselves.

Neither Mr. Coquillett nor Mr. Koebele observed any bird feeding upon it. The reason for this exemption is probably the copious secretion of wax, which is doubtless distasteful. Several reliable persons report that ducks and chickens feed greedily upon those scale-insects which are dislodged from the trees. * * * * *

Predaceous Insects.—The only predaceous insect observed by Mr. Coquillett to feed upon the Cottony Cushion-scale was the larva of a species of Lace-wing fly (*Chrysopa* sp.), which was not bred and cannot be named more exactly.

The Ambiguous Lady-bird (*Hippodamia ambigua*) has been noticed feeding upon the eggs when they were exposed to view by the egg-sac being broken open; but neither this nor any other species of Lady-bird was seen to feed upon the adult insect, although commonly attracted by the honey-dew secreted.

Among the predaceous insects found by Mr. Koebele and sent to us for study we may mention first the larva of a small moth (*Blastobasis iceryæella* n. sp.), although as yet we are not certain that it ordinarily preys upon the living and uninjured scale-insects or their eggs. Like certain other so-called predaceous Lepidoptera, it may be attracted primarily by the waxy secretions of the bark-lice, and only incidentally destroy the insects and their eggs. These larvæ were often found feeding in the egg-masses of females which had been destroyed by soap washes, and also in sacs the eggs of which had hatched some time previously, but never upon fresh eggs. One of the larvæ, kept in a glass tube with living scales and fresh eggs, fed slightly on the waxy mass, but did not thrive until after the scales died. It then fed upon the dead scales and moulted, but died before transforming. Two nearly full-grown larvæ fed readily on dead scales which were still soft, and passed through their transformations successfully. The same insect fed readily upon the Black Scale (*Lecanium oleæ*), in this case eating the living insects and their eggs, forming a silken tube along the twig, and passing from one scale to another, just as does the Coccid-eating Dakruma (*Dakruma coccidivora*)* in feeding upon the Cottony Maple-scale at the East.

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The most efficient destroyer of the Cottony Cushion-scale at Los Angeles is perhaps a species of earwig, family Forficulidæ neither the genus nor species of which we are able to determine, from the fact that we have only seen immature specimens. According to Mr. Koebele this insect is often met with among the scales, and, from observations which he made, feeds greedily upon the Icerya in all stages, tearing open the egg-masses and eating the eggs, and also tearing and eating the mature insects as well as the larvæ.

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* We have bred a species of *Dakruma* the past season, indistinguishable from *D. coccidivora*, from the Cochineal insect (*Coccus cacti*) received from Dr. A. F. Carrothers, of San Antonio, Tex., who collected the specimens at his ranch (Iuka ranch) near Cotulla, La Salle County, Texas.

In a recent communication from Miss Ormerod, already mentioned on p. 196, she writes as follows of a predaceous insect discovered by her correspondent, Mr. Bairstow, of Port Elizabeth, Cape Colony :—

"It will perhaps be of some interest to mention that Mr. Bairstow has found a species of Coccinella which has proved (as far as our coleopterists are aware) to be previously undescribed, to be so exceedingly serviceable in destroying the 'Australian bug,' as they call it, that he has been supplying it to applicants. Dr. Baly examined the specimens sent over for me, and I propose to notice it, with full technical description and a figure, as *Rodolia iceryæ*."

Parasites.—It is a somewhat remarkable fact that no true parasites were ever bred from the Cottony Cushion-scale until the past summer, and still more remarkable that in the course of their careful investigations, extending over a space of six months, neither Mr. Coquillett nor Mr. Koebele succeeded in finding a single parasite upon this insect. From a number of scales, however, sent to Washington by Mr. Koebele, November 10, we bred, on December 8, two specimens of a small Chalcid, which is, without question, a true parasite of Icerya, as the female scales from which they escaped were found each with a small round hole in its back.

This little parasite is prettily marked with black and yellow. It is new to our fauna and may have been imported with its host.*

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Remedies and Preventive Measures.

We have indicated in the introduction to this report the more important results of the experiments carried on at Los Angeles by Messrs. Coquillett and Koebele, and as their reports are later given in full we shall refrain from entering into detail here, and state only a few of the more important convictions that impressed us after the first week's experience in the orange groves of California.

Importation of Parasites.—The general importance of the introduction of parasites which affect a species in its native land, and which have not accompanied it into the land of its introduction, has been insisted on in our earlier writings and in those of others, and the ease with which this may be done in the case of the more minute parasites of scale insects adds to its importance in their connection. Considering the fearful losses already occasioned to California orange growers by two species (the *Icerya* in question and the California Red Scale), introduced from Australia, we know of no way in which the Department could more advantageously expend a thousand dollars than by sending an expert to Australia to study the parasites of the species there and secure the safe transport of the same to the Pacific coast; and the fact that the Commissioner of Agriculture is prevented from doing so by restrictions imposed on the Division of Entomology is a sad commentary on the narrow Congressional policy which seeks to limit and control administrative action in details which can neither be properly understood nor anticipated by committees.

Preventive Action.—The value of clean culture and fertilizing where necessary to induce vigorous growth, but more particularly of wise pruning, so as to let in the sun and rain to the heart of the tree, has been set forth in the special report of the Division on the Insects affecting the Orange, by Mr. Hubbard, and apply equally to California

* This parasite is described by Mr. Howard as *Isodromus Icerya*, How.

as to Florida. We have also been particularly impressed with the value of wind-breaks of coniferous trees not affected by the Coccidæ that infest the Orange, both as shelter to the trees and as screens to prevent the spread of the *Icerya* from invested trees outside the grove.

Spraying with Insecticides.—The orange-growers of the Pacific have suffered greatly from the advice and recommendations of biased or interested persons, who were prejudiced in favour of their own particular remedies, and were for a long time unwilling to profit by the results of thorough and careful experiments which we have for some years conducted in the East, and which are in the main embodied in Mr. Hubbard's report. A pretty thorough personal survey of the field has convinced us that while the resin soaps experimented with by Mr. Koebele are a valuable addition to our insecticides for the orange Coccidæ, yet in the main our experience in Florida is repeated in California, and all the more satisfactory washes have kerosene as their effective base. There has been, and is, however, a very great waste in applying it, and where from 10 to 50 or more gallons have been used on a single tree, from 2 to 4 would suffice.

We cannot urge too strongly the fact that in the case of this *Icerya*, as most other orange-feeding Coccidæ, it is practically impossible, with the most careful and thorough spraying, to reach every one of the myriad individuals on a good-sized tree. Some few, protected by leaf-curl, bark-scale, or other shelter, will escape, and with their fecund progeny soon spread over the tree again if left unmolested. Hence two or three sprayings at intervals of not more than a month are far preferable to any single treatment, however thorough; and this is particularly true of the *Icerya*, which occurs on so many other plants, and which in badly-infested groves is crawling over the ground between trees. It is now the custom to use the time of a team and 2 men for fifteen to twenty minutes or more, and 10 gallons and upward of liquid on a single medium-sized tree. In this way the tree is soaked until the fluid rains to the ground and is lost in great quantities, some growers using sheet-iron drip-plates around the base of the tree to save and reuse the otherwise wasted material. This is all wrong so far as the oil emulsion is concerned, as the oil, rising to the surface, falls from the leaves and wastes more proportionally than the water.

The essence of successful spraying of the kerosene emulsion consists in forcing it as a mist from the heart of the tree first and then from the periphery, allowing as little as possible to fall to the ground and permitting each spray particle to adhere. It is best done in the cool of the day, and, where possible, in calm and cloudy weather. With one fifth of the time and material now expended in California the spraying should be successfully done, so that three sprayings at proper intervals will be cheaper and far more satisfactory than only one as ordinarily conducted. In this particular neither Mr. Coquillett's nor Mr. Koebele's experiments are entirely satisfactory, as we were so far from the field while they were being carried on as to render any special direction of them impossible. Both strove for the practically impossible, viz., the destruction of all insects by a single application. Mr. Koebele's estimate of the cost of the kerosene wash is also too high, as he used it much stronger than necessary. The resin compounds may doubtless be used to advantage in connexion with the kerosene emulsions; but anything which will give permanence and preventive character to the wash will add greatly to its value. Without going into details as to reasons, we would therefore recommend the addition to every 50 gallons of the kerosene-soap wash, made after the usual formula, 3 ounces of arsenious acid. Though the arsenical preparations are mainly effective against

mandibulate insects, by poisoning through the stomach, they have also more or less effect by contact, and we are strongly of the opinion (which we hope soon to verify) that this combination, for the first time recommended, will give the spray most lasting effect, and that the few insects which escape the direct spray will be destroyed as they subsequently leave their protecting retreats or hatch from eggs and crawl about the tree. As a means of arresting the growth of the black-mould (which is, however, only the indirect consequence of the Coccid), so troublesome an accompaniment of the *Icerya*, a small proportion of sulphate of copper might also be added.

Just as there is now a great wastage of time and material in drenching a tree, so the spraying nozzle most in vogue in California is also wasteful. That most commonly used is the San José nozzle, in which the water is simply forced through a slightly flaring terminal slit in a more or less direct and copious jet. The force and directness of the spray give this nozzle its popularity under the mistaken spraying notions which prevail, and to this we must add the fact that, being a patented contrivance, it is well advertised and on the market.

The cyclone nozzle has not yet had proper trial to impress its advantages, having scarcely been known prior to the experiments of Messrs. Coquillett and Koebele. That made and sold by G. N. Milco is patterned in size and aperture after that which we designed to spray from near the surface of the ground. What is wanted for an orange grove or for trees is a bunch of nozzles of twice the ordinary size and capacity, the size of the outlet to be regulated by the force of the pump. There is no form of nozzle so simple and so easily adjustable to all purposes. We strongly recommend a bunch of four nozzles of twice the ordinary size and thickness, one arranged so as to have the outlet distally or at one end of the piping (which may be ordinary gas-pipe) and the other three on branches, so that the outlet is at right angles, each about an inch below the other, and so placed that they are separated by one third the circumference of the main pipe. Such a bunch, with apertures properly adjusted to the occasion, worked from the centre of the tree, will envelop it in a perfect ball of floating mist, which in a very short time will imbue all accessible parts. For tall trees a more forcible direct spray might be sent from the end by substituting an ordinary jet and the wire extension, which is simply an extension tube screwed over the nipple, the end of the tube being covered with wire netting, which breaks up the liquid forced through it, and which for force and fine division of the particles has some advantages over the San José nozzle. Finally, if a series of blind caps and several sets of caps of varying aperture are kept on hand, the spray may be adjusted at will, and to suit the conditions of wind, pump force, &c. that have to be dealt with.

Fumigating.—Fumigating the trees will always have the disadvantage, as compared with spraying, that the mechanism is more cumbersome, the time required greater, and the first cost in making preparation heavier; and these factors will always give spraying the advantage with small proprietors or those who have to deal with young trees. As an offset to these drawbacks fumigation has the merit of more effectually reaching all the insects upon a tree, and this alone would under some circumstances justify the greater first cost and trouble in preparing movable tents for the purpose, providing always that a gas, vapour, or fume be discovered that will rapidly kill all the insects without injuring the tree; virtues not easily combined in such subtile media.

In Florida proper spraying has been found to be so effectual and satisfactory that no elaborate experiments in fumigating have been

undertaken, and we are fully satisfied that proper spraying will also prove sufficient in California. But so much poor work has been done and so many defective washes used that many growers have become discouraged and quite a disposition has been shown to either cut down the trees or resort to fumigation as a last resource. In connection with Mr. Alexander Craw, Mr. Coquillett has conducted some experiments in the Wolfskill orchard at Los Angeles, which lead them to believe that they have discovered a gas which possesses the requisite qualities, and trees that had been treated and which we examined pretty carefully would seem to justify their hopes. Several ingenious movable-tent contrivances are also being developed in Los Angeles County that give promise of practical utility and feasibility, and which we may have more to say about on some future occasion.

Bandages around the Trunk.—There is always danger that a tree once sprayed will get reinfested from the insects that have not been reached upon adjacent plants or upon the ground, and which in time crawl up the trunk. Any of the sticky bandages used for the canker-worm will check this ascent, but when placed directly on the trunk may do more harm than good. They should be placed upon strips of tar or other stout paper or felting, tied by a cord around the middle, the upper end flared slightly outward, and the space between it and the trunk filled with soil, to prevent the insects from creeping beneath. Cotton should not be used for this purpose, as birds for nesting purposes carry away particles of it containing the young insects, and thus help to disseminate them.

Conclusion.—All possible care should be taken in cultivating and harvesting the crop to prevent dissemination of the young upon clothing, packing-boxes, &c., and too much care cannot be exercised in endeavours to prevent the introduction of the species from infested to non-infested regions. Next to destructive locusts no insect has been more fully legislated against than this *Icerya* in California. Yet while some good has resulted, the laws have too often proved inoperative, either through the negligence or ignorance of the officers appointed to execute them, or, more often, the indifference of the courts and their unwillingness to enforce them with vigour.

The pest has come to stay. No human endeavour can exterminate it. But it may be controlled, and while the greatest possible co-operation should be urged, and, if possible, enforced, yet each orange-grower must in the end depend upon his own exertion; and we say to them, individually and collectively, that there is no occasion for discouragement. This insect has made profitable orange-growing on the Pacific coast more difficult and more of a science; but, by making it impossible at the same time for the shiftless to succeed in their business, it will come to be looked upon as a not unmixed evil.